

**Part A: The Productivity Measures of a Firm**

Table 3-2.1 is a short-run production chart showing how the productivity of the firm changes as it adds additional units of labor to its fixed stock of capital. Assume the data refer to the firm's productivity in a one-week period.

1. Complete Table 3-2.1. Some data are already included in the chart. Put the values of MPP at the new labor level. For example, when the firm increases its labor from one to two units per week, its total output increases by 15 units. Write "+15" at  $L = 2$  in the MPP column.



Table 3-2.1

**The Three Productivity Measures of a Firm**

L	Q	MPP = $\Delta Q / \Delta L$	APP = $Q / L$
0	0	—	—
1	10	<b>+10</b>	10.0
2	25	+15	<b>12.5</b>
3	36	<b>+11</b>	<b>12.0</b>
4	46	<b>+10</b>	11.5
5	55	+9	<b>11.0</b>
6	63	<b>+8</b>	<b>10.5</b>
7	63	<b>+0</b>	9.0
8	60	-3	<b>7.5</b>

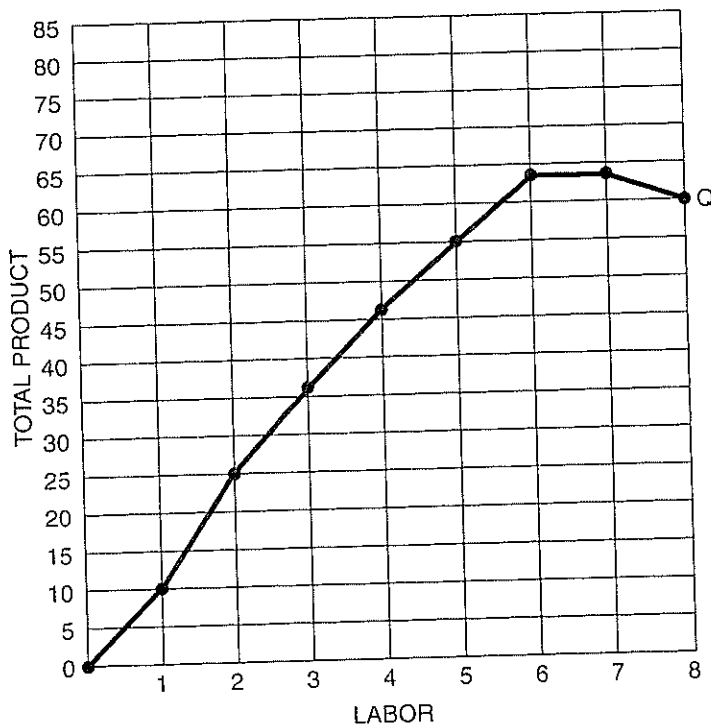
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### SOLUTIONS ACTIVITY 3-2 (CONTINUED)

2. When you have completed Table 3-2.1, plot the L and Q data in Figure 3-2.1. (The first two combinations are plotted for you already.) This Q curve shows how much total output the firm produces with different amounts of labor. Note that the firm's total product increases as it adds more labor, but eventually the total product declines if the firm adds too many labor units on its limited amount of equipment.



Figure 3-2.1  
Total Product

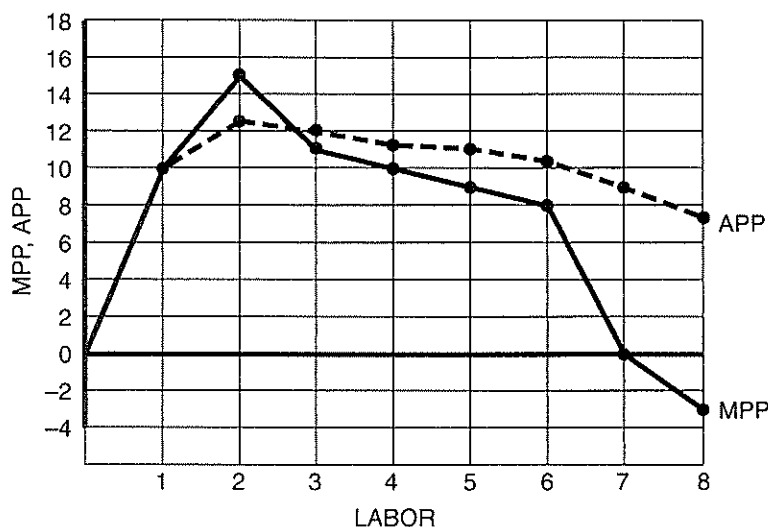


3. Now plot the L, MPP, and APP data in Figure 3-2.2. You can connect the MPP points with a solid line and the APP points with a dotted line. (Some combinations are plotted for you already.) Plot the values of MPP at the new labor level. For example, put a dot on the graph at the combination of  $L = 2$  and  $MPP = +15$  since the MPP resulting from adding the second labor unit is 15 units of output. Note that both MPP and APP increase initially but then decrease as the firm adds more units of labor.



Figure 3-2.2

## Marginal Physical Product and Average Physical Product



4. Diminishing marginal productivity sets in with the addition of the third labor unit.
5. The average physical product continues to increase as long as the marginal physical product is (greater than / equal to / less than) the average physical product.
6. Can the average physical product of labor be negative? Why?  
*APP cannot be negative because it is the ratio  $Q/L$  and neither  $Q$  nor  $L$  can be negative.*

7. Can the marginal physical product of labor be negative? Why?  
*Yes, because MPP shows the change in Q when an extra labor unit is added. If Q decreases when labor is increased, then MPP will be negative.*
8. Total product increases as the firm adds units of labor as long as the marginal physical product is (positive / zero / negative).
9. Although our graphs have no information about the price of the good or the price of labor, we can conclude that the firm will not want to hire a unit of labor for which marginal physical product is (diminishing / negative). Explain your answer.  
*As long as MPP is positive, Q is increasing. This is true even if MPP is diminishing. It is possible that the extra unit of labor adds more to the firm's total revenue than to its total cost. But if MPP is negative, that means Q decreased when an extra unit of labor was hired. A firm will not want to pay for an extra worker if its total output decreases; its total profit will decrease if it does.*
10. What is the relationship between marginal physical product and total product?  
*The relationship between MPP and Q can be expressed as follows:*
- (1) *If MPP is positive, Q will increase.*
  - (2) *If MPP is zero, Q will not change as Q is at its maximum value.*
  - (3) *If MPP is negative, Q will decrease.*
11. What is the relationship between marginal physical product and average physical product?  
*The relationship between MPP and APP can be expressed as follows:*
- (1) *If MPP is greater than APP, APP will increase.*
  - (2) *If MPP is equal to APP, APP will not change as APP is at its maximum value.*
  - (3) *If MPP is less than APP, APP will decrease.*

### Part B: Productivity and Cost: A Mirror View of Each Other

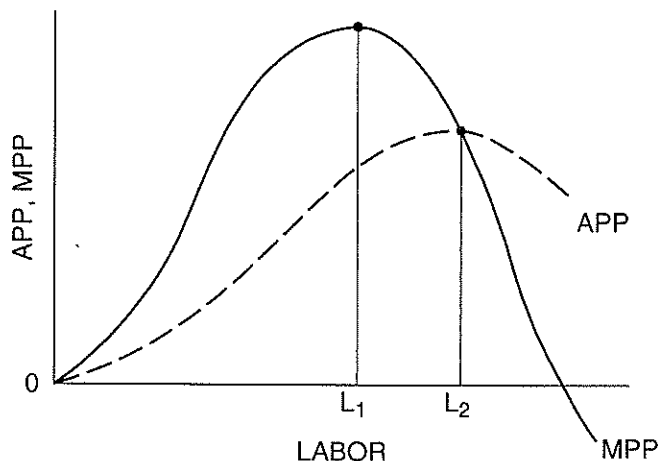
As you work with productivity and cost graphs, note how the axes are labeled. The productivity graphs typically have L on the horizontal axis because that is the variable resource that the firm changes in order to alter its level of total output. The vertical axis has some measure of productivity (such as Q or APP). There are no dollar signs on a productivity graph because such graphs are not dealing with revenue or cost. The cost graphs always have total output or total physical product (Q) on the horizontal axis because costs are expressed in relation to the Q of the firm. Cost graphs always have a dollar-measured concept on the vertical axis (such as total cost [TC] or marginal cost [MC]).

Figure 3-2.3 shows the relationship between a firm's MPP and APP. The graph assumes MPP initially increases as the firm adds labor units due to specialization of labor on the firm's equipment. Eventually diminishing marginal productivity sets in, which means that at some point APP also will decline as more labor units are added.



Figure 3-2.3

## Marginal Physical Product and Average Physical Product



12. Diminishing marginal productivity sets in at  $(L_1 / L_2)$  labor units.

13. APP increases as long as MPP is (greater than / equal to / less than) APP.

14. APP decreases as long as MPP is (greater than / equal to / less than) APP.

15. Why is APP maximized at  $L_2$  labor units?

*APP is maximized at  $L_2$  labor units because that is where  $MPP = APP$ . Before that quantity of labor, MPP is greater than APP so APP is increasing. Beyond that quantity of labor, MPP is less than APP so APP is decreasing.*

16. "If MPP is diminishing, then APP must also be diminishing." Is this a correct statement? Why?  
*This is an incorrect statement. There is a range of labor of units for which MPP is diminishing but APP is increasing because MPP is still greater than APP. In Figure 3-2.3, this is between  $L_1$  and  $L_2$  labor units.*

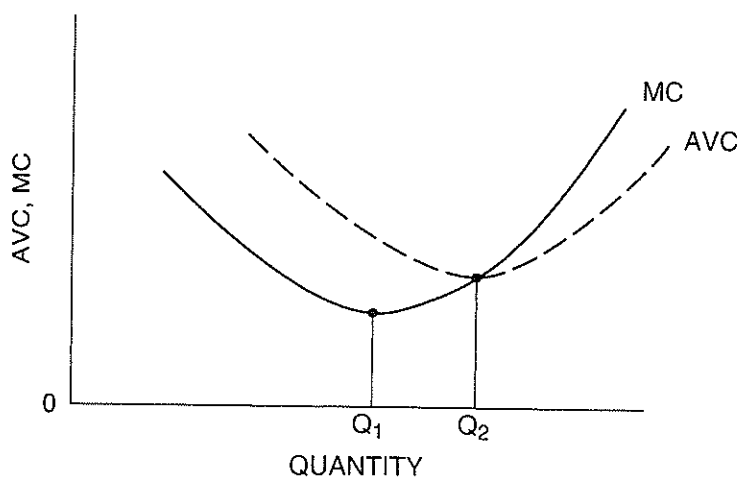
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### ACTIVITY 3-2 SOLUTIONS (CONTINUED)

Figure 3-2.4 shows the relationship between a firm's MC and AVC:  $AVC = TVC/Q$ . If the firm has L as its only variable resource, then AVC represents the labor cost per unit of output. Suppose a firm pays each of its 10 workers a daily wage of \$80 and produces a Q of 400 units. Its TVC is \$800 = (10)(\$80), and its AVC is \$2 = \$800/400. Each of its 400 units has a labor cost component of \$2.



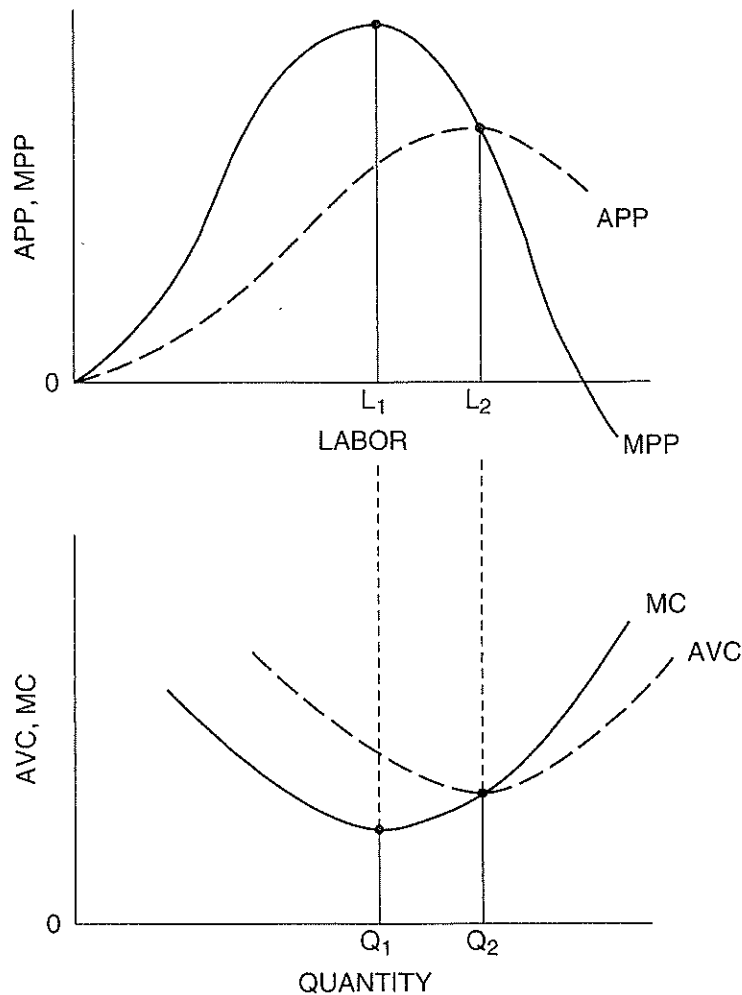
Figure 3-2.4  
Marginal Cost and Average Variable Cost



17. AVC decreases as long as MC is (*greater than / equal to / less than*) AVC.
18. AVC increases as long as MC is (*greater than / equal to / less than*) AVC.
19. Why is AVC minimized at  $Q_2$  units of output?  
*AVC is minimized at  $Q_2$  units because that is where  $MC = AVC$ . Before that quantity of output, MC is less than AVC so AVC is decreasing. Beyond that quantity of output, MC is greater than AVC so AVC is increasing.*
20. "If MC is increasing, then AVC must also be increasing." Is this a correct statement? Why?  
*This is an incorrect statement. There is a range of output units for which MC is increasing but AVC is decreasing because MC is still less than AVC. In Figure 3-2.4, this is between  $Q_1$  and  $Q_2$  output units.*



Figure 3-2.5  
**Mirror Image of Productivity and Cost Measures**



The productivity of a firm is the basis of its cost. A firm wants to be highly productive in order to keep its costs low. Refer to Figure 3-2.5 to answer the following questions based on a firm's productivity and cost measures. Assume outputs  $Q_1$  and  $Q_2$  are produced by this firm when it uses  $L_1$  and  $L_2$  labor units, respectively.

21. As long as the MPP of labor is increasing, the MC of producing extra units of output will (increase / not change / decrease).

22. As long as the MPP of labor is decreasing, the MC of producing extra units of output will (increase / not change / decrease).
23. The MC of producing extra units of output will be minimized when the MPP of labor is maximized at  $L_1$  labor units and  $Q_1$  output units.
24. As long as the APP of labor is increasing, the AVC of producing output will (increase / not change / decrease).
25. As long as the APP of labor is decreasing, the AVC of producing output will (increase / not change / decrease).
26. The AVC of producing output will be minimized when the APP of labor is maximized at  $L_2$  labor units and  $Q_2$  output units.